THURSDAY, JANUARY 19, 1871

THE MEDITERRANEAN ECLIPSE, 1870

CLOUD in Sicily, cloud in Spain, cloud in Africa. Such at first sight might seem to be the only result of all the observations made on the eclipsed sun of 1870; such the reception given by Nature to those who wooed her as she had never been wooed before, who approached her full of the rarest gifts which Science has placed at man's disposal.

But, after all, has the oracle been silent? I think not. Dare we, however, say that the great problem of the Corona, that one among the many still outstanding difficulties which the eclipse was invoked to settle, is settled? This, perhaps, would be saying too much, but still, I think, a step in advance has been made. The oracle has spoken darkly perhaps, but it *has* spoken.

Let me endeavour to put the question as it stood a few weeks ago as briefly as possible.

Beginning the story some few years back we find the corona, a halo of white light round the moon, with a height sometimes represented as equal to the moon's diameter, sometimes more, sometimes less, with a border *à discrétion*,—so much did the drawings vary—regarded as the solar atmosphere.

Some thought the red prominences to be mountains, other observers called them clouds.

The polariscope was brought up with a view of determining whether the corona shone by reflected light or not. The result of this new method of observation was doubtful.

In the Indian eclipse of 1868 M. Janssen, by means of the spectroscope, still another aid, determined that the prominences were masses of hydrogen gas, but there was no final word about the corona. Major Tennant observed that its spectrum was continuous. Later in the same year Dr. Frankland and myself approximately determined the pressure of the prominence gases by means of the new method and laboratory experiments, and at once stated our conviction that the extensive corona which had been depicted and represented by Kirchhoff and others to be the solar atmosphere must be something else. This was our idea. I cannot quote our words, for I am writing in Venice and have no copies of our paper with me.

In the American Eclipse of 1869 the problem was advanced considerably, perhaps even more considerably than we can yet form an idea of, writing as we must still do doubtfully. I do not refer to the drawings, for they varied considerably, but to the observation that the light of the outer corona, like that of the prominences, gave a bright-line spectrum. But as at least some of the observers gave positions doubtfully, "near C" and "near E," I thought that the explanation was still possible which regarded the corona as of terrestrial origin; that is, which assumed it to be an appearance due to the presence of light in our own atmosphere. The problem was one of such difficulty that there seemed a possibility that, by some unexplained cause, some of the solar light might be diffused and beat out of its course, and then, mixing up with the light of the chromosphere, give us a sort of continuous spectrum, with the hydrogen bright lines superposed upon it; in other words, that as the eye perceives a bright, irregular region or glare around the uneclipsed sun, an effect due to our atmosphere, so also the eye might perceive a bright, irregular region or glare round the *uneclipsed chromosphere during eclipses*, due also to our atmosphere.

One word here about the Chromosphere, the name I have given to the bright-line-giving region outside the photosphere. It has long been clear that the spectroscopic method of observing it when the sun is not eclipsed is not totally effective; that is to say, that we only see a per-centage of it—perhaps only a relatively small per-centage—but the glowing prominences, that is, those in which there is no evidence of the rapid motion of ejection from the sun, the ejection taking place at all angles from the line of sight, afford evidence that there is probably a layer of cooler hydrogen susceptible of being rendered visible above the ordinary level. Now as these prominences may be 5′ high, it is not unreasonable to suppose that the chromosphere may even extend to that distance, or even a little beyond it.[*]

Hence it was that in the Instructions to Observers, drawn up by Professor Stokes and myself, and approved by the Organising Committee for this 1870 Eclipse, it is stated that—

"The PRINCIPAL OBJECT to be obtained is to determine whether it is possible to differentiate the outer layers of irregular outline and the streamers (of the corona) from a stratum, say some 5′ or 6′ high, round the sun, which may possibly be the limit of the gaseous envelopes above the photosphere."

The spectroscopic observers, therefore, were enjoined—

a. "To determine the actual height of the chromosphere as seen with an eclipsed sun; that is, when the atmospheric illumination, the effect of which is doubtless only partially got rid of by the Janssen-Lockyer method, is removed. If the method were totally effective, the C line, the line of high temperature, should hardly increase in height; but there can be little doubt that the method is not totally effective, so the increase in height should be carefully noted."

b. "To determine if there exists cooler hydrogen above and around the vividly incandescent layers and prominences."

And the polarisers—

"To examine a detached and selected part of the corona about 6′ from the limb of the sun, and say about 8′ in diameter."

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[*] Here is what I wrote on this point a year ago:—"I next come to the obliterating effect of the illumination of our atmosphere on the spectrum of the chromosphere. This is considerable; in fact, the evidences of it are very much stronger than one could have wished, but hardly more decided than I had anticipated. Professor Winlock's evidence on this point, in a letter to myself, is as follows:—'I examined the principal protuberance before, during, and after totality. I saw three lines (C, near D, and F) before and after totality, and eleven during totality; *eight were instantly extinguished on the first appearance of sunlight*.'" This effect was observed with two flint prisms and 7 inches aperture. Professor Young, with five prisms of 45° and 4 inches aperture, found the same result in the part of the spectrum he was examining at the end of the totality He writes:—'I had just completed the measurements of 2602, when the totality ended. *This line disappeared instantly*, but 2796 [the hydrogen line near G] was nearly a minute in resuming its usual faintness.' These observations I consider among the most important ones made during the eclipse; for they show most unmistakeably that, as I have already reported to the Secretary of the Government-Grant Committee, the new method to be employed under the best conditions must be used with large apertures and large dispersion." (Proc. R. S. 1870, p. 181.)

Having got so far, it may be here stated that of the three means of attack, namely, the spectroscope, the polariscope and telescope, and naked eye observations, the spectroscopic method, under certain circumstances, might have been by far the most doubtful, the polariscope method coming next.

With regard to the spectroscopic observations, if we assume that no light whatever is received by and from our own atmosphere, the observations would be easily translated. A pure continuous spectrum would reveal to us solid or liquid matter in the circumsolar regions; a spectrum continuous or not containing bright lines would give us gases or vapours; the ordinary solar spectrum, with its dark lines, would indicate matter incapable of radiation itself, and therefore cool, reflecting to us ordinary sunlight. It is clear that the problem would be complicated if circumsolar matter both reflected sun light and sent us its own; and still more so if we allow that the coronal light may be partly contributed from reflections and refractions in our own atmosphere. Then we have to consider whether the light thus contributed may possibly be due to the photosphere or to the prominences, and we are landed in a maze of difficulties which need not be discussed here.

The system of sketching introduced for this eclipse is at once so simple and final that the only wonder is it has not been introduced before. The corona must be either solar, atmospheric, or subjective, that is, more or less built up in the observer's eye, this more or less depending *cæteris paribus* upon the brilliancy of the undoubted solar portion. If at all stations, the stations being as wide apart as they have been this time, the drawings are similar, then the corona would be undoubtedly cosmical; if dissimilar, then it would either be terrestrial or subjective: and this point could and would have been settled this time, if the weather had permitted, by arranging the observers *in pairs*, that is, dealing with two observers in each place instead of a single one, and so obtaining the eye-variation.

This being premised, what is the result of the very few observations, comparatively speaking, which have been made? Before I attempt to give any idea of my answer to this question, it is only fair to myself to state that my only sources of information, up to the present time, have been conversations with some of the American members of the Sicilian expedition, a brief telegram from the members of the English party at Agosta, the Rev. S. J. Perry's communication to the *Daily News* of the 2nd instant, and an inspection of some drawings made by the officers of H.M. ships off Aci Reale. At Catania we saw a portion of the corona for 1½ seconds through a cloud, and that was all; and the day after the eclipse, before the more fortunate members of my party returned, it became my duty to proceed to Malta in H.M.S. *Lord Warden* to attend the court-martial on the officers and crew of the beautiful, but unfortunate, *Psyche*, in which we had been wrecked on the 15th ult., and the weather in the Mediterranean has been so bad that it was impossible to leave Malta in time to rejoin the expedition before they left for England. Of detailed information, therefore, I have none.

In the first place, then, I submit that the fact that the corona is a compound phenomena comes out in an unmistakable way. We have first of all a ring some 5′ or 6′ high round the moon, which almost all observers have seen alike; and then we have light beyond which some observers have seen of one shape and some of another, now stellate with many rays, now stellate with few, now absolutely at rest, now revolving rapidly.

This I think to be the key-note of all the observations with which I have become acquainted. I need scarcely say that it is exactly what had been predicted.

First among the fortunate ones who observed the corona with the telescope was Prof. Watson, of Ann Arbor, who took up his station at Carlentini, and appears to have been the best favoured among the Sicilian observers. From his account I gather that there was an almost perfect *shell* around the sun about 5′ high, and that outside this shell were less definite rays. What he was particularly struck with was this, that, as seen in the telescope, the rayed portion was most developed over the prominences, and, as I gathered from him in one case, the rayed portion was absent as if a veil had been removed; so that he, at all events, is strongly impressed with the idea that the shell represented a true solar appendage, and that the rayed structure was due to our own atmosphere.

Next comes Mr. Brett, who, although he was not so fortunate, still was enabled to see and place on record some most interesting features, including the whole outline of the corona and even some of the protuberances. He also, as I am informed, saw the rayed portion of the corona most developed above the protuberances, the outline of the interior portion being visible, though not so strongly marked as in the case of Prof. Watson's drawing, in consequence of less favourable atmospheric conditions. I am thankful to say that the weather at Syracuse enabled Mr. Brothers to obtain some admirable photographs, which I have not yet seen. These are among the most important results of the Expedition.

Next I must mention Prof. Peirce, the head of one of the American parties, who observed two miles north of Catania, at a private casino of the Marchese Sangiuliano. I believe that he also saw the shell, but of this I am not absolutely certain; but he distinctly observed that the outer corona over the prominences was rosy red, although he did not see the prominences himself. A more beautiful proof of the terrestrial nature of this portion of the corona it would be difficult to imagine: for, of course, at the sun, the hydrogen, which thus tinged it, is incapable of colouring anything, as its own light is absorbed by the transcendent brilliancy of the photosphere; while nothing would be more natural than to suppose that the light, which, in its own atmosphere, should strongly tinge anything radially illuminated, should be that of the prominences.

But the strongest proof of the variability of the outer portion and of the constancy of the inner portion is afforded by the observations made on board the small fleet attempting to save the *Pysche* off Aci Reale, where the eclipse was observed in unclouded splendour. Here were the ironclads *Lord Warden*, *Caledonia*, and *Royal Oak*, and the tugs *Weasel* and *Hearty*, besides the Italian gunboat *Plebiscito*, all within a stone's throw of each other. In all the drawings, and many have been received, we have a ring 5′ or thereabouts, while the outer portion is as variable as may be. On the same deck, that namely of the flag-ship, *Lord Warden*, two drawings were made, one by Captain Brandreth, and the other by Dr. Macdonald, F.R.S., in which the variation is so strong that one would feel inclined to acquit the atmosphere of any participation in the matter, and to relegate the whole outer corona to subjectivity alone, did not Mr. Brothers's admirable photographs show both phenomena, as I am told they do. Dr. Macdonald saw eight rays arranged with perfect symmetry; Captain Brandreth saw only two elliptical hoops crossing each other at right angles.

Captain Cochran, of the *Caledonia*, besides the ring, saw a complicated stellate figure, the rays of nearly equal length, while Mr. Dexter, at sea between Catania and Syracuse, saw, besides the ring, *only one ray* of inordinate length.

So much for the drawings. I think that if the records of former eclipses be now examined, especially Mr. Carrington's drawing of the eclipse of 1851, and compared with the others taken at the same time, additional evidence will be gathered in favour of the compound nature of the corona, which, on the evidence now before me, I consider the great teaching of the present eclipse. Our experience in Sicily seems to be similar to that of the Spanish observers, for Mr. Perry writes that "some observed two curved rays," while the rapid degradation of light occurred at one-fifth of a solar diameter, but, so far as I know, no one in Sicily was favoured with a view of the dark intervals which were observed in Spain.

There is a strange and most interesting discordance between some of the spectroscopic observations made in Sicily and Spain. At Agosta, where the totality was well visible for ten seconds, Mr. Burton detected a green line near E, with a tangential slit (distance from moon not stated). This line, which was also seen by the Italian observers, is doubtless the one recorded last year by the American astronomers, but in Spain Mr. Perry states that bright lines at C near D, *b* (or E) and F were observed 8′ away from the sun. At Syracuse Prof. Harkness, whose telescope was moved into the various positions by Captain Tupman, R.M.A., found the green line in all parts of the corona, so far as about 10′ from the sun, and at one point thought he detected two green lines, less refrangible than it; but at several places he saw a complete hydrogen spectrum (including C), which he attributed to prominences, until he was informed by Captain Tupman that there was no prominence near the slit. More proofs of the terrestrial nature of this portion of the corona, I think, taken in connection with the fact that *the dark moon gave identically the same spectrum.* It would appear that there was so much atmospheric reflection in Spain, and here and there at Syracuse, that the true coronal spectrum with its line near E, the existence of which we must now accept as established beyond all question, was partially masked by the prominence spectrum with its usual well-known lines. There is one passage in Mr. Perry's interesting letter in which, if there be a misprint, as I suspect there is, an observation of great importance is recorded. It runs, "Mr. Abbay, observing at Xeres with a spectroscope of 2 prisms of 45° belonging to Professor Young, saw the bright lines C, D, F; and afterwards F and a line rather more bright than F on the less refrangible side of B, C not noticed then." Now, if *b* (not B) was intended here we have sub-incandescent hydrogen mixed with the green-line-giving-substance, which may probablybe a new element with a vapour density less than hydrogen.

So that roughly we might regard the chromosphere to be built up of the following layers, which are in the orders of vapour density in the case of known elements:—

X′ (new element)		Green coronal line
Hydrogen	Sub-incandescent	F
	Incandescent	C, F, near G, h
X (new element)		Near D
Magnesium		*b* and lines in blue and violet
Sodium		D
Barium		Several lines
Iron, &c.		Several lines, including E

The foregoing table excludes naturally the substance or substances which give bright lines in the solar spectrum, which are at times visible in the spectrum of the chromosphere. I have ventured to suggest that the substance which gives the line in the green is a new element, because invariably I have found that in solar storms the chromospheric layers are thrown up in the order of vapour density, and because all the heavier vapours are at or below the level of the photosphere itself.

With regard to the question of polarisation, the parties in Sicily obtained evidence that the corona was radially polarised, though Professors Harkness and Eastman obtained a result which they explain differently. Mr. Ranyard, at Villamonda, and Mr. Peirce, jun., north of Catania, obtained identical results in favour of strong polarisation. Hence the solar corona, accepting these observations, not only radiates, but reflects solar light to us. A careful consideration of this fact, taken in connection with the possible addition of a, so to speak, terrestrial corona to its light, may enable us to account for some of the observations, both polariscopic and spectroscopic, which do not at first appear to harmonise with those to which I have referred, notably those which give a pure continuous spectrum to the corona, and which state that its light is only slightly polarised.

From what has preceded, then, we seem justified in suggesting as working hypotheses the following, which, however, more accurate information may alter, and which I offer as suggestions only, *bien entendu*.

1. The Solar Chromosphere extends some 5′ or 6′ from the sun (Watson and others), its last layers consisting of cool hydrogen (Mr. Abbay), and possibly a new element with a green line in its spectrum (Young, Burton, and others); which line, if it be identical with the auroral line as stated by Gould, may possibly be present in the higher regions of our own atmosphere.

2. Outside this stratum the rays, &c., are for the most part due partly to our own atmosphere, partly to our eyes, for their shape varies; they are seen by some at rest, by others in motion, and their spectrum is the same as that of the dark moon (Maclear).

3. The white light of the chromosphere above the prominences, as seen in an eclipse, is due to its strong reflection of solar light, as shown by the polariscopic observations (Ranyard, Peirce, jun., Ladd).

4. The rosy tinge of the corona proper, that is of the region more than 5′ or 6′ from the sun, is due to our atmosphere containing light which comes from both the higher and lower strata of the chromosphere (Peirce, sen., Maclear, Abbay).

Venice, Jan. 9 J. NORMAN LOCKYER

A HEARTH OF THE POLISHED STONE AGE

Note sur un Foyer de l'Age de la Pierre polie découvert au Camp de Chassey en Septembre, 1869. Par Ernest Perrault. 1870. 4to. Pp. 32, and 8 plates. (Chalon sur Saône, L. Landa. London: Williams and Norgate.)

ON the summit of a steep hill between the valley of the Bas Roches and that of the Dheune, overlooking the immense plain of the Saône and commanding a view of the Jura, the Alps, and the mountains of the Maconnais and the Morvan, and surrounded by numerous other camps, is the camp of Chassey, which occupies an area of about 800 yards in length by a breadth varying from about 100 to 200 yards. So commanding and important a spot was not only taken possession of by the Romans for a *castellum* and by the Gauls for an *oppidum*, but was also occupied in prehistoric times. Several collections of antiquities belonging to different periods have been formed upon the spot, but it was reserved for M. Perrault to make the interesting discovery which he has recorded in so simple yet so complete a manner in the pages now before us. A terrace, sheltered by rocks from the north and east winds and facing the morning sun, seemed to him well adapted for early habitations, while a depression in the ground in front proved, on examination, to contain the remains of a large hearth, or it might be termed kitchen, and here he instituted excavations.

Beneath a few inches of soil he found a bed rather more than two feet in thickness, made up of ashes, bones, and pottery, and containing numerous instruments of various kinds. The whole reposed on a platform of rough slabs of stone, blackened like the soil beneath them by the action of fire. Not a trace of metal was discovered, and in describing the objects found, M. Perrault divides them into (1) instruments of stone, (2) those of bone, and (3) pottery.

Exclusive of fragments some 150 stone instruments were found, consisting for the most part of hatchets, arrow-heads, flakes, borers, scrapers, hammers, mealing stones, and polishing stones. No less than eight perfect stone hatchets were found, as well as fourteen broken, and of those that were uninjured two were still mounted in stag's-horn sockets, similar to those with which the discoveries in the Swiss Lake dwellings have made us so well acquainted.

Only two are of flint, and one of fibrolite, the others being of chloromelanite, serpentine basalt, and diorite. They seem to have been formed from pebbles brought down by the Saône, and it is interesting to observe that the same process of manufacture was in use in this part of Burgundy as in Switzerland, the splitting of the pebbles into the required form having been partly effected by sawing. That some of the spare hours of those who frequented the hearth were employed in preparing their hatchets is proved by the large number of grinding or polishing stones, of which, counting fragments, upwards of sixty were present. M. Perrault regards one of the smallest of the cutting instruments, a little triangular celt, as a religious emblem, but it seems more probable that it was used as a hand-tool, like a chisel, of one of which the sharpened end was also found.

The arrow-heads of flint, twenty-three in number, present a variety of forms, leaf-shaped, triangular, lozenge-shaped, and tanged, the latter both with and without barbs. Their general aspect is such as might have been expected from the locality, most of the forms occurring also in Switzerland. There are, however, one or two shaped like small hatchets, with a broad sharp base, formed by the original edge of the flake from which they were made, and rounded or truncated at the other end. It is stated that this sharp edge was intended for insertion in the wood, but more probably it was the other end that was thus secured, and the arrows were, so to speak, chisel-pointed, like the flint-tipped arrows which survived in use, probably for fowling purposes, after metals became known to the ancient Egyptians. Similar arrow-heads, if such they be, have been found in considerable numbers in Sweden, and a few in Denmark, as well as in some other parts of France. It seems by no means impossible that some of the sharp-based instruments from the Yorkshire Wolds may have served a similar purpose.

The mealing stones consist of a large block, usually of hard sandstone or porphyry, and a smaller stone as muller, and are of the same character as those still in use in Central Africa. They must have been gradually eaten together with the flour they produced, and no doubt tended to promote that wearing away of the crown of the teeth so common in ancient times. None of the grain has been found, but probably most of the cereals known to the old Swiss Lake dwellers were also known at Chassey.

The objects in bone and horn are almost identical with those from the earlier Swiss Lake dwellings, and consist of the sockets already mentioned, awls, chisels, &c. The pottery, which is extremely fragmentary, is much of the same character as the Swiss. It has been ornamented both by punctured dots and by a sort of pillar moulding as well as by incised lines. In one instance there seems to have been an attempt to represent the outline of a boar by lines scratched in the clay when still moist. In another, the ornament consists of bands of triangles alternately cross-hatched and plain, a style more in accordance with the bronze age than with that of stone. Most of the pottery seems to have been adapted for suspension. The number of small ears or handles found exceeded 200. A few spindle-whorls and beads were also found, but the most curious objects are the spoons, exactly similar in form to those of wood in common use in our kitchens at the present day, but formed of clay. It is true that several wooden ladles and at least one earthenware spoon were found in the settlement of Robenhausen, but one can hardly repress a feeling of surprise at finding the spoon so fully and completely developed among a people apparently unacquainted with the use of metal, though it is true that they appear to have had the materials for porridge at their command.

In concluding this short notice of a valuable contribution to prehistoric archæology, a regret must be expressed that the animal remains discovered in the refuse heap have not, apparently, as yet been submitted to proper scientific examination, so as to determine the species, and which of